GLOBALIZATION AND STRUCTURAL CHANGE IN THE US MANUFACTURING SECTOR, 1987-2010
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Abstract
This paper investigates the impact of globalization on structural changes in the US manufacturing sector. It finds that US productivity in the manufacturing sector has increased, but that the performance of the sector is highly contingent on changes in US national income. Changes in manufacturing output responds adversely to shocks that are associated with US national income and manufacturing import, but the negative effect of the income shock on US manufacturing dominates and outlasts that of the manufacturing import shock. Empirical evidence also indicates a dual-causal relationship between national income changes and employment changes in the US manufacturing sector.

JEL F16, F20, F43, J23
Key Words: Globalization, Income Shock, Manufacturing, VAR

1. Introduction

This paper investigates the impact of globalization on structural changes in the US manufacturing sector. It finds that US productivity in the manufacturing sector has increased, but that the performance of the sector is highly contingent on changes in US national income. Changes in manufacturing output responds adversely to shocks that are associated with US national income and manufacturing import, but the negative effect of the income shock on US manufacturing dominates and outlasts that of the manufacturing import shock. Empirical evidence also indicates a dual-causal relationship between national income changes and employment changes in the US manufacturing sector.

Globalization may mean different things to different people and different disciplines, but in this paper it is conceptualized as the economic integration resulting from technological innovation. The impulse to its development is productivity and economic growth, which has spurred the expeditious circulation of goods and services as well as consumption. Stiglitz (2003) aptly characterizes it as “the closer integration of the countries and peoples of the world which has been brought about by the enormous reduction of costs of transportation and communication, and the breaking down of artificial barriers to the flows of goods, services, capital, knowledge, and (to a lesser extent) people across borders.” Bhagwati (2004) observes that globalization is normally smuggled into a galling description of exploitative child labor to unfairly suggest its affinity with nefariousness. In this paper, structural change alludes to inter-sectoral shifts, the restructuring of trade rules and the resulting implications for structural unemployment.

The consequences of internationalization, including equity, have been controversial; essentially because some nations have become poorer, a newer category of workers are increasingly becoming structurally unemployed, and the global economy has become more susceptible to systemic risk and global recessions because of the newer and higher

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levels of interdependence. A new wave of global crisis involving richer nations, which transcends the traditional debt crises of poorer countries in Africa, Latin America, and Asia, is now becoming more apparent than imaginary.

Of course, although globalization involves the pace of innovation, the removal of international trade barriers (economic integration), and the transformation of the cost of production, the use of cheaper labor has caused consternation in various countries of the world, partly because the productivity gains that are associated with integration, have also heightened concerns about poverty, environmental degradation, and structural change, albeit with varying degrees of intensity in different countries of the world.

In the US, structural change has usually been associated with the paradigm-shift of employment from manufacturing to the service or other related sectors, but also intra-sectoral changes involving the elevated needs of human capital. Some have attributed the new structural unemployment to outsourcing and offshoring. Yet, the service and manufacturing sectors have their own share of outsourcing and are largely interdependent, with reasonably good evidence of linkages.

Using changes in manufacturing output, changes in employment in the US service and manufacturing sectors, corporate tax receipts and changes in manufacturing imports, this paper examines the performance of the US manufacturing sector in the globalized world while also evaluating the response of the sector to import and national income shocks. The rest of the paper is structured to provide the relevant framework for analysis. Section 2 provides an overview of the pertinent globalization and manufacturing literature. The econometric variables of interest are discussed in Section 3 and the methodology of the paper is presented in Section 4. The significant empirical findings and conclusion are provided at the end of the paper.

2. The Globalization and Manufacturing Literature

The review of the relevant globalization and manufacturing literature can be summarized under the following broad categories: (i) cheaper cost of production in manufacturing as a result of technological innovation, liberalization and outsourcing; (ii) difficulties associated with the measurement of outsourcing and manufacturing productivity; (iii) the controversial employment outcomes in manufacturing as a result of plant construction, extinction, and technological innovation; (iv) wages for labor in manufacturing; and (v) the cyclical effects of economic performance on manufacturing output and employment.

Diet and Orr (2006) allude to the practical effect of globalization on U.S. manufacturers and its irreversibility—an increase in the availability of new sources of low-cost labor and manufacturing capacity, which has also made production cost a competitive issue in the global economy in which goods and capital are mobile, but labor is not. As such, the primary impulse for manufacturers to tap into lower-cost labor by importing it in the form of lower-cost parts, components, and increasingly as finished goods is simply a function of trying to stay competitive in a global economy. Hence, the trend toward sourcing parts and components globally is driven by powerful competitive forces that are irreversible.

Globalization-induced low-wage competition reallocated labor within manufacturing; but Sachs et al. (1994) note that the low-wage competition did not only reallocate labor within manufacturing, it actually resulted in net job losses in manufacturing. They point
out that the net job loss can occur under several scenarios: (i) when the low-wage workers have a positive supply elasticity, so that a decline in their wage leads to a decline in labor force participation; (ii) when low-wage workers are unionized, and unions maintain wages above full employment levels; or (iii) when low-wage workers have alternative employment opportunities in nonmanufacturing (such as services) so that they leave the manufacturing sector entirely when international competition puts downward pressure on wages. Their suspicion is that all of the scenarios or responses have been important in shaping the job loss in manufacturing, but general equilibrium analysis cannot provide very comprehensive answers to all the questions about wage changes.

The contribution of the foreign sector to manufacturing unemployment or contraction is not well settled in the literature. Lawrence and Slaughter (1993) and Krugman and Lawrence (1994) note that competition from abroad has played a minor role in the contraction of U.S. manufacturing; a view that was subsequently supported by Sachs et al. (1994). The consensus that these scholars seem to have in common is that increased internationalization cannot by itself account for most of the observed labor market trends; partly because the overall changes in employment and in wage inequalities are too large to be explained by changing trade and price patterns that were observed from c.1979 to the early 1990s. In effect, it is likely that technological innovation can play a role that is independent of internationalization; albeit that the relative importance of trade and technology cannot be precisely measured because of the difficulties that are associated with pinning down the values of technological change.

Krugman and Lawrence observe that the link between competition abroad and the contraction of the manufacturing industry is mostly spurious, and to the extent that a real linkage exists, that it may be very small. They observe that a missing variable worth scrutinizing is the secular trend, since well before the rapid internationalization of the economy, which started in the 1970s, the decline was due mainly to a secular decline in the relative price of manufactures compared with nonmanufactures; largely due to the relatively rapid growth of productivity in manufacturing.

If one assumes an aggregate price elasticity of demand of less than one, the secular fall in the relative price of manufactures translates into a declining share of consumption of manufactured goods, and thereby (assuming balanced international trade) into a declining share of manufacturing production in GDP (Sachs et al.). Corrado and Mattey (1997) and Houseman et al. (2011) have also drawn attention to national economic performance. For example Houseman et al. note that the manufacturing sector never rebounded after the 2001-2002 recession as it had done in the previous recessions and between 1997 and 2007 manufacturing employment declined by 20 percent or roughly by 3.4 million jobs. The net number of manufacturing establishments fell by 8 percent from 1997 to 2007. Though the sector has not performed dismally, it has exhibited greater cyclical swings for which it has made outsized contributions to changes in GDP growth during economic turning points (Corrado and Mattey, 1997).

Steep employment declines and strong output growth are commonly explained by high productivity growth in the manufacturing sector, but the literature reflects skepticism about the data on robust output and productivity growth in the manufacturing sector. Houseman (2007) discusses reasons why manufacturing productivity statistics should be interpreted with caution, especially as a result of the recent growth of domestic and foreign outsourcing and offshoring. Cost savings that are the result of outsourcing or
offshoring to capitalize on cheaper labor are usually counted as productivity gains even in multifactor productivity calculations. Additionally, it is well noted that the measurement of productivity, growth, and value added attributed to offshoring (sometimes defined as the substitution of imported goods and services for domestically produced goods and services) can be misleading.

The more recent study by Houseman et al identifies the dominant effect of computers and electronic products manufacturing to the perception of productivity growth. Although computer and electronics products account for only about a tenth of manufacturing value added, the sector contributed two-thirds of overall manufacturing growth in real value added from 1997 to 2007 (Houseman et al.). It is worth juxtaposing this finding with their observation of the way and manner in which the measurement of productivity and value added in manufacturing has been affected by the dramatic rise in imports of manufactured goods, which more than doubled from 1997 to 2007. In particular, they focus on imports of intermediate goods into the manufacturing sector. Using the Bureau of Economic Analysis (BEA) data, they note that the import share of intermediate material inputs used by manufacturers increased from under 17 percent in 1997 to 25 percent in 2007—a dramatic shift in sourcing of intermediate goods from domestic to foreign suppliers.

They further went on to show effects of offshoring by decomposing the growth of real gross output into the parts resulting from the growth of inputs to production and from multifactor productivity growth (the part of output growth that cannot be accounted for by the growth of factor inputs). In their calculation, the inputs are a weighted average of the growth rate of labor, capital, energy, services, domestic materials, and foreign materials. The weight on each input is used to represent the input’s share of total costs. They found that the contribution of multifactor productivity growth to real output growth is very strong and that the contribution of labor is negative and large, which reflects the steep employment declines between 1997 and 2007. They also uncovered a rapid pace of structural change in US manufacturing. Between 1997 and 2007 the contribution of domestically supplied material inputs fell, while that of imported material inputs greatly expanded, reflecting the substitution of foreign for domestic intermediate inputs. It is evident from the literature that globalization entails cost minimization and employment displacement (structural unemployment). The cyclicality of economic performance and contraction of domestic and foreign investment demand has been identified as a source of trouble for the manufacturing sector by manufacturers themselves.

Dietz and Orr extend the analysis to examine the displacement of workers on the skill spectrum. They find that though international competition tends to displace U.S. workers at the low end of the skill spectrum, where foreign labor is most plentiful and least expensive, heightened globalization and productivity have led to the creation of high skill jobs and job losses for low-skilled workers [a symptom of creative destruction]. They find that technology advances promote the development of high-skill jobs in engineering.

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1 In a March 2003 speech to the National Association of Manufacturers in Chicago, U.S. Secretary of Commerce, Donald Evans, launched the Manufacturing Initiative to create the conditions necessary to foster U.S. competitiveness in manufacturing and stronger economic growth at home and abroad. Manufacturers were able to identify a broad array of issues bedeviling the manufacturing sector, including corporate taxes, regulation, health care cost, tariffs, available human capital, cyclicality of economic performance, and domestic and foreign absorption; see US Department of Commerce (2004).
research and development (R&D), and other specialized fields. Increased trade can also lead to an expansion of these same kinds of jobs in export industries. The job-creating and displacement effects of trade and technology have led to a reallocation or restructuring of the types of jobs performed in the manufacturing sector (Dietz and Orr). To determine the nature and extent of restructuring, Dietz and Orr examine the changing composition of the manufacturing workforce using 1983-2002 data on occupations and wages from the Current Population Survey, a monthly household survey conducted by the Bureau of the Census for the Bureau of Labor Statistics. Yet, some scholars have questioned the dominant role of technological innovation in the determination of employment in manufacturing.

Dunne, Roberts, and Samuelson (1989) quantify the role of plant construction, expansion, contraction, and closing in generating net and gross changes in U.S. manufacturing employment from 1963 to 1982. They use longitudinal data set constructed from the plant-level observations, from which the reallocation of employment opportunities across and within sectoral, regional and cohort boundaries can be measured. They found that over 70 percent of the turnover in employment opportunities occurs across plants within same industry and geographic region. Systematic differences in the employment fluctuations of plants of different ages are also found. Their research examines the process of plant creation, expansion, contraction, and closing that generated variations in employment demand in the U.S. manufacturing sector over the 1963 to 1982 period.

In addition to industry and regional shifts, their study examines the gross employment flows that arise from the entry, growth, and exit of plants of different ages or entry cohorts. The econometric evidence presented shows that as a cohort of plants ages, the extent of employment loss through plant contraction increases, while employment loss through plant failure and employment gain through plant expansion both diminish. The employment turnover process thus arises primarily from the entry of new plants, the expansion or failure of young plants, and the gradual contraction of older plants. This contrasts with the common view that plant turnover is primarily the replacement of old outdated plants by new plants with more modern technology.

The pertinent literature can be summarized as follows: (i) that cost-minimizing opportunities emanate out of globalization, hence its competitive outcome; (ii) the measurement of productivity gains associated with internationalization can be murky; (iii) the contraction of US manufacturing can be attributed to globalization; (iv) globalization can also result in disproportionate effects on the skill spectrum in manufacturing; (v) plant construction, expansion, contraction, and closing can be unrelated to globalization; and (vi) the cyclicality of economic performance and domestic and foreign absorption also have effects on employment in the US manufacturing sector.

Some central elements of the literature provide a basis for the selection of econometric variables and further inquiry. As such, further analysis of the literature will be discussed as part of the variable selection process. The literature raises two issues of probative interest in this paper; (i) the contribution of some economic variables to manufacturing growth in the US; and (ii) the response of manufacturing growth to critical shocks involving national income and imports of manufacturing goods. The next section discusses the econometric variables.
3. The Econometric Variables

Manufacturing Output

The performance of the extensive US manufacturing sector has been pointedly linked to globalization and data from the US Manufacturing Institute (MI) show that the U.S. share of global value added in manufacturing has remained relatively steady at around 22 percent since 1980 (MI, 2009, p.1). US manufacturing has been keeping pace with that of the overall economy in terms of physical output and the manufacturing sector, which has a higher multiplier effect than other economic sectors and pays higher wages relative to the service sector. In 2008, the sector generated $1.64 trillion worth of goods and between 1998 and 2008 the manufacturing value added increased by 22 percent (MI, p.3).

The literature on the competitive viability of the sector as a result of globalization is conflictive. While some have expressed pessimism about the globalization-induced structural changes, others have been more cautious. O’Toole and Lawler III (2006) noted that contrary to conventional wisdom, manufacturing is far from dead in the United States (US). There are over 100,000 manufacturing companies offering high-tech and unique products and the US manufacturing sector accounts for 23.8 percent of the world’s total manufacturing output in 2004, as measured in value-added terms.

What has declined, they noted, is the percentage of American workers employed in manufacturing, which declined about 15 percent in about three decades (starting from the 1970s to about 2006 when they wrote their book). It is believed that the growth in service sector employment has somehow offset the shrinkage in manufacturing employment (O’Toole and Lawler III). Notably, with the penetration of technological innovation, some of the companies that were once characterized as manufacturing companies—IBM, Xerox, General Electric, Sun, and Cisco, pivoted from their purely manufacturing status to the service-oriented status. In effect, most of their profits and growth come from services rather than manufacturing. This has implications for measuring sectoral tax receipts.

The controversy over the effects of structural changes has been further complicated by the dominance of the computer and electronics segments of the manufacturing sector and the measurement of productivity in the sector (Houseman et al.). As a result, the manufacturing conundrum and structural changes create interesting opportunities for further inquiry. The consensus in the literature seems to affirm the declining employment in the manufacturing sector, but the reasons for the decline in employment are variegated.

Of course, these reasons include the cyclical nature of national income, the cost of production, and the cost-savings of globalization or internationalization. Invariably, the cost of domestic production is normally compounded by the less conspicuous tort expenses. The total cost of U.S. tort claims is estimated to exceed $250 billion a year, or over 2 percent of GDP (MI, 2009, p. ii). It is noteworthy that the sector is interdependent and has forward linkage effects. Attempts to study the sector in isolation may therefore be problematic. The data for manufacturing output are compiled as average quarterly changes in an index of manufacturing output from 1987 to 2010 and can be obtained from the economic research division of the Federal Reserve Bank of St. Louis. The index provides good econometric opportunity to minimize the effect of biased representation associated with the computer and electronic industry.
Real Gross Domestic Product

National income is a robust measure of economic performance in monetary terms. The real measure adjusts for price movements over time so that the actual quantity of goods and services can be determined. While national income is not an adequate measure of well being or equity, it provides a reasonable estimate of aggregate income, which tends to be positively correlated with aggregate consumption and production. As such, it is a variable that tracks the propensity to increase investment demand and consumption of manufacturing goods. This variable is of interest because it reasonably tracks the cyclicality of economic performance and the corresponding response of the manufacturing sector as well. The correlation between economic performance and the manufacturing sector is well noted in the literature. For example, Torayeh, (2011) finds that there is a long run circular causality between manufactured exports and economic growth. Houseman et al have also drawn attention to the importance of overall economic performance.

Recessions are typically very hard on manufacturing. Of the eight recessions preceding 2004 and going back to the 1950s, manufacturing output declined by 7 percent, while real GDP declined on average by about 2 percent. As a result, manufacturers generally want the US government to focus on economic growth at home and abroad (US Department of Commerce, 2004). The GDP data is operationalized as seasonally adjusted quarterly growth rate from 1987 to 2010 and is obtained from the Federal Reserve Bank of St. Louis.

Manufacturing Imports

This variable is relevant because it mirrors the substitution of domestic production as a result of the cheaper cost of production in foreign markets. It potentially captures three effects: the substitution effect associated with consumption; the substitution effect associated with factor input; which should ultimately have an effect on employment in the manufacturing sector; and an intermediation effect associated with the imports of intermediates. If the intermediation effect is very strong, this variable should positively affect the growth of US manufacturing through cost savings; except of course, if absorption is very weak in domestic and foreign markets.

Low wages in the developing countries create an incentive to relocate physical capital to foreign countries were resource cost is cheap for production and re-export to the United States. Such capital flows would depend on low transport and communications costs, an open trade regime in the developing country and the United States, and the developing country's openness to foreign direct investment, or other kinds of capital flows (Sachs et al). Such conditions did not apply widely in the developing world until the 1980s and can now be found much more widely pervasive because of technological innovation.

To the extent that capital is internationally relatively mobile than labor, the structural change creates adverse economic conditions and structural unemployment. The displacement of labor that can be attributed to technological innovation is somewhat reminiscent of the displacement of workers during the European Industrial Revolution of the nineteenth century. This is because revolutionary technological changes that impinge on the use of labor have natural implications for the labor force of a country.
The literature indicates that the measurement of manufacturing can be problematic. This is mainly because of the dominance of computers and electronic products in US manufacturing. Although computer and electronics products account for only about a tenth of manufacturing value added, the sector contributed two-thirds to the overall manufacturing growth in real value added from 1997 to 2007. (Houseman et al.). Houseman and others further noted that between 1997 and 2007 the import of manufactured goods more than doubled and created controversy over the measurements of productivity and value added in manufacturing. They found that the import share of intermediate material inputs used by manufacturers increased from under 17 percent in 1997 to 25 percent in 2007—a dramatic shift in sourcing of intermediate goods from domestic to foreign suppliers. Although the share of imports has increased, Figure 1 shows that the manufacturing import index (MIMP), which starts from the fourth quarter of 1989, is dwarfed by the manufacturing output index (MANUO); thereby suggesting a wide manufacturing output-import discrepancy. This can be partly attributed to productivity in the manufacturing sector (see Figure 2). The import variable is operationalized in terms of seasonally adjusted average quarterly changes and can be accessed from the Federal Reserve Bank of St. Louis.

**Figure 1: The US Manufacturing Output-Import Differential 1987/9-2010**

Employment in the manufacturing sector is stratified and contingent on a number of variables, including: the quality of human capital; health care cost; alternative opportunities (including employment in the service sector); and the intensity of
outsourcing. As a result, the variable is somewhat confounding and its volatility may not be singularly attributed to internationalization. However, the variable provides very useful information when it is evaluated against the growth of manufacturing output to extrapolate the productivity effect of innovation when cost-saving from outsourcing becomes more elusive or confusing.

Employment in the manufacturing sector has been badly affected not only by outsourcing, but by adverse recessions. The cyclicality of economic performance became much more detrimental to the computer and high-tech industries. For example, employment in computers and electronics fell 24 percent from the fourth quarter of 2000 to the third quarter of 2003, and the decline in employment in electrical equipment was of similar magnitude (US Department of Commerce, 2004, p. 19).

Technological innovation brought with it an important sectoral change—the requirement of a skilled workforce. The requirement demands training and cost, but the skill requirement for some US manufacturing companies is usually not attained by some workers who are making their debut into the US workforce relative to competing foreign markets. As the manufacturers noted, physical skills are no longer more important than mental skills in the auto industry and even a solid high school-level education is no longer enough to remain relevant in today’s manufacturing sector. Hence, by the turn of the twenty-first century manufacturers started to look for workers who had training beyond high school, up to and including four years of college for entry into the manufacturing workforce. The changing demand is evidently based on the need for skills to deal with increasingly complex capital equipment used in today’s manufacturing processes (US Department of Commerce, 2004, p. 50).

Bureau of Labor Statistics (BLS) data show that the number of workers in manufacturing remained fairly invariant from 1970 (17.8 million workers) through 2000 (17.3 million workers), after which the sector experienced a steady decline. In 2005, 14.3 million people worked in manufacturing. However, the proportion of manufacturing jobs has fallen from 30.6% of all nonfarm jobs in 1955 to 10.7% in 2005. In contradistinction to the manufacturing sector, the service-providing industries accounted for 83.4% of nonfarm employment in 2005.

The employment variable is important for at least two reasons: (i) it is complementary to production in the manufacturing sector, and therefore performs a useful theoretical function, and (ii) it potentially mirrors the unemployment effect of structural changes that have been brought about by economic integration and access to cheaper labor abroad. Data for this variable have been collected from the BLS for all employees in manufacturing and have been operationalized in the form of average quarterly changes from 1987 to 2010.

The National Association of Manufacturers observes that 97 percent of its members continue to voluntarily support employer-provided healthcare in spite of the growing cost of these benefits and the sluggish economy for manufacturing. By 2004, the percentage of employers providing coverage did not decline substantially. In spite of rising costs, employers did not increase the percentage of the premium paid by employees, but to avoid shifting more of the costs to the actual consumers of healthcare services, employers, particularly those in small and medium-sized manufacturing firms, had to find ways to contain costs and become competitive (US Commerce Dept., 2004).
Employment in the Service Sector

The service sector has witnessed considerable employment boom since the 1970s as a result of technological innovation. Consequently, the sector has made an important contribution to the growth of employment, productivity and innovation in member countries of the Organization of Economic Cooperation and Development (OECD, 2007). In the US, the sector has accounted for an increasing amount of workers. The business services sector, which deals with computer services, research and development (R&D), IT-consulting legal, accounting, marketing and advertising, business consulting human resource development (professional services), and operational services like cleaning, secretarial, and security services, has been growing rapidly in most OECD countries.

Services that were produced locally, which are also fundamentally essential to modern businesses, like software development, R&D, and other knowledge-intensive service activities are being extensively outsourced, but the booming service sector has provided theoretical and real outlets for unemployed workers in the manufacturing sector looking for employment. But firms have also increasingly purchased knowledge-intensive services from external sources in order to take advantage of economies of scale. In 2007 the share of the business services sector as a percent of GDP was recorded to be as high as 12-13 percent in France and the US (OECD, 2007, p.6).

The service sector is of particular importance to the economy as a whole because it has significant forward linkages with other sectors. That is, inter-relationship with the rest of other industries in an economy that is heightened by further demand for services. Forward-linkages show what would happen to a given industry if the final demand of every other industry were to increase marginally (OECD, 2007, p.9).

By 2000, the number of US workers in the service-providing sector was 107.1 million, compared with 24.6 million in the goods-producing sector. However, in 2005, Bureau of Labor Statistics data show that US workers who provided services (111.5 million) outnumbered workers who produced goods (22.1 million) by a ratio of five to one. The data for this variable is operationalized in terms of quarterly changes in the total number of employed workers (sixteen years and older) in the service sector from 1987 to 2010. Information for estimating this variable has been obtained from the BLS.

Corporate taxes

Manufacturers generally tend to see taxes as impediments to the prosperity of manufacturing, especially small-sized manufacturing businesses (US Department of Commerce, 2004). For example, despite the reductions in capital gains and dividend taxes, as well as expensing provisions, many manufacturers believed that the recent US tax cuts did not go far enough. They emphasize the need to create greater certainty under the tax code, including better depreciation schedules, in order to encourage business investment. Yet, the call for tax reform is not only directed to production possibilities, but real reforms that will target the consumption of manufacturing goods. A thorny issue is the volatility or prospective volatility of changes in tax rates and the uncertainties of manufacturing performance that accompany prospective tax changes.

Interestingly, far from encouraging companies to move offshore, manufacturers argue that the Internal Revenue Code (IRC) contains significant penalties on income derived from foreign investment, which sometimes leads to double taxation. Competition in the
global economy requires marketing investment abroad, but income from such investments is susceptible to taxes, thereby imposing costs for competing in the global economy. The corporate tax variable is important for a variety of reasons. Theory suggests that manufacturing output is a function of the cost of production, including taxes. But outsourcing and taxation may also generate undesirable effects of tax evasion and avoidance, resulting in increased illegal savings and corporate profits.

The variable therefore presents probative value to the inquiry of manufacturing performance though there are difficulties associated with a straightforward measurement of taxation in sectoral terms, essentially because of aggregation and IRS classification, the avenue from which the data are obtained. As such, the instrumental variable of changes in corporate tax receipts from 1987 to 2010 is utilized. This instrumentality also corrects for overlapping sectoral income and leakages that can be attributed to tax evasion and avoidance.

One of the peculiar changes associated with the new globalization (post 1970s) is not only the integration of the global economy, but the inter-sectoral integration that accompanied the winds of change. For example, the reconfiguration of the Fortune Industrial 500 to form a newer Fortune 1000 in 1995 was largely the result of inter-sectoral changes—the synthesis of manufacturing and business services in some corporations—which made it increasingly difficult to assign companies to one sector or the other (O’Toole and Lawler III). While the Fed data officially classifies the sectors, it is quite cumbersome to delineate the sectoral sources of tax revenue. However, to the extent that the variable estimates aggregate changes in tax receipts, one might expect the variable to have a significant impact on the manufacturing sector or some form of retardation for the sector. In reality, the empirical evidence is less precise. The next section discusses the methodology of the paper.

4. Methodology

The scientific method of this paper is designed to: firstly, estimate the incremental effects of selected variables on change in US manufacturing; and secondly, examine the response of the manufacturing sector to unexpected changes in national income and the import of manufacturing goods. The conventional rules for external validity are taken into consideration and various tests are performed to prevent significant errors in estimation and inference. The cross-sectional and quarterly time series data already alluded to are used to accomplish the broader bifurcated objectives of evaluating the explanatory power of the exogenous variables and examining the response of manufacturing output to the relevant shocks.

To accomplish the first objective, the White [heteroskedasticity-consistent standard errors and covariance] estimator is used.\(^3\)

The White estimator (Ω\(^*\)) takes the following form:

\(^3\) White (1980) derived a heteroskedasticity covariance matrix estimator, which provides consistent estimates of the coefficient covariances in the presence of conditional heteroskedasticity of unknown form.
\[
\Omega^* = \left( \frac{T}{T-K} \right) \sum_{t=1}^{T} \left( \frac{e_t^* X_t X_t^\prime}{T} \right); \\
(1)
\]

where \( e^* \) is for the estimated residuals, \( T \) is for the number of observations, \( K \) is for the number of regressors, \( X_t X_t^\prime \) is for the variance-covariance matrix, and \( T/(T-K) \) is the degree of freedom correction. In abbreviated form the OLs can then be written as:

\[
y^* = x^* \beta + u^*, \quad \{ y^* = \frac{y}{\sqrt{\Omega^*}}; \quad x^* = \frac{x}{\sqrt{\Omega^*}}; \quad \text{and} \quad u^* = \frac{u}{\sqrt{\Omega^*}} \} \quad (2)
\]

Correcting for heteroskedasticity is a theoretically and empirically reasonable procedure because volatility in economic performance, imports, and corporate tax receipts may cause the temporal (as distinct from cross-sectional or spatial) variance of the errors to show uneven variations. However, apart from the estimator of preference, the operationalization of the macro-variables in terms of growth rates empirically minimizes the presence of heteroskedastic errors in estimation.

Since it is usual for macroeconomic variables to exhibit collinear relationships, the variance inflation factors (VIFs) are examined. The result of the variance inflation test is reported in Table 1.

**Table 1: Variance Inflation Factors**

<table>
<thead>
<tr>
<th>Dependent Variable: Manufacturing Growth.</th>
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<tr>
<td>Included Observations: 95 (after adjustments)</td>
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</table>

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Coefficient Variance</th>
<th>Uncentered VIF</th>
<th>Centered VIF</th>
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<tbody>
<tr>
<td>Change in employment</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(manufacturing sector)</td>
<td>0.05</td>
<td>2.16</td>
<td>1.88</td>
</tr>
<tr>
<td>Change in employment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(service sector)</td>
<td>0.003</td>
<td>1.57</td>
<td>1.56</td>
</tr>
<tr>
<td>Change in real GDP</td>
<td>8.87E-06</td>
<td>6.30</td>
<td>1.65</td>
</tr>
<tr>
<td>Corporate tax receipts</td>
<td>1.63E-06</td>
<td>1.34</td>
<td>1.21</td>
</tr>
<tr>
<td>Available human capital</td>
<td>0.004</td>
<td>1.95</td>
<td>1.36</td>
</tr>
<tr>
<td>Constant</td>
<td>7.06E-06</td>
<td>6.53</td>
<td>NA</td>
</tr>
</tbody>
</table>

The VIFs are a method of measuring the level of collinearity between the regressors in an equation. They show the amount of estimated variance of an estimated coefficient of a variable that has been inflated as a consequence of collinearity with other stimulus variables. The Table reflects exceedingly low coefficient variances for the independent variables.\(^4\) The operationalization of variables in terms of their growth or changes

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\(^4\) They can be calculated by simply dividing the variance of a coefficient estimate by the variance of that coefficient had other regressors not been included in the equation. Eviews 7 reports the centered VIF, which is the ratio of the variance of the coefficient estimate from the original
minimizes the problem of serially correlated errors. Alternatively, data in first differences may be used to reduce multicollinearity, non stationarity and autocorrelation (Heim, 2009).

To accomplish the second objective, an examination of the response of manufacturing growth to national income and manufacturing import shocks, the impulse response function is utilized. The function is theoretically specified as a moving average (MA) representation of the vector autoregressive (VAR) system of equations; traditionally specified as Equation 3:

\[ Y_t = \mu + \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \cdots + \Psi_p \varepsilon_{t-p}, \quad \{ \text{for } p=2 \text{ in this case.} \} \]  

Thus the matrix \( \Psi_j \) has the interpretation:

\[ \frac{\partial y_{t+s}}{\partial \varepsilon_i} = \Psi_j; \]  

where the \( i \)th row and element in the \( j \)th column of \( \Psi_j \) identifies the effects of a one unit increase in the unexpected changes attributable to the \( j \)th variable in the system of equations at date \( t \) for the value of the \( i \)th variable at time \( t+s \) holding all other innovations constant, with the notable exception that regularity conditions can be imposed. Alternatively, the innovations or shocks can be orthogonalized for the purposes of identification. This is usually done by Cholesky factorization or by the generalized system suggested by Pesaran and Shin (1998), which is not sensitive to causal ordering:

\[ \Psi_j = \frac{1}{\sqrt{\sigma^2_j}} B^n \Sigma \delta_j; \]  

where \( \sigma^2_j \) is the variance of the \( j \)th innovation, \( \Sigma \) is a symmetric matrix of standard errors; \( \delta_j \) is for the \( j \)th innovation, and \( B^n \) is for a row vector of variables. The sequential and generalized shocks are compared, but only the generalized shocks have been reported.

VARs have traditionally been used to examine the interaction of macroeconomic variables for forecasting, variance decomposition, impulse response analysis, cointegration and dual-causality (Granger) tests; examples include: the very influential work of Stock and Watson (2001); Wijeweera and Mounter, (2008); and Torayeh (2011). A much more direct application of the use of VAR to the study of manufacturing and economic growth and causal relationships can be found in the work of Torayeh.

Practical use of the Wold (1938) representation (Equation 3), requires VARs to be stable rather than explosive. This is typically done by checking for lag length and an examination of the roots and moduli. The relatively stringent Schwarz information equation divided by the variance from a coefficient estimate from an equation with only that regressor and a constant. On the contrary, the uncentered VIF is the ratio of the variance of the coefficient estimate from the original equation divided by the variance from a coefficient estimate from an equation with only one regressor (and no constant).
criterion is used for lag-length determination and the stability result is reported in Table 2. Eviews 7 reports the inverse roots and moduli, which are all found to be within the unit circle, suggesting that the VAR is invertible or stable. The Granger-causality test is used to examine the predictive power of the variables and the empirical findings of this paper are reported in the next section.

Table 2: Stability Condition for Cholesky and Generalized Orthogonalizations

<table>
<thead>
<tr>
<th>Roots</th>
<th>Modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.837545</td>
<td>0.837545</td>
</tr>
<tr>
<td>-0.732031</td>
<td>0.732031</td>
</tr>
<tr>
<td>0.634859 - 0.244963i</td>
<td>0.680480</td>
</tr>
<tr>
<td>0.634859 + 0.244963i</td>
<td>0.680480</td>
</tr>
<tr>
<td>0.009478 - 0.376747i</td>
<td>0.376866</td>
</tr>
<tr>
<td>0.009478 + 0.376747i</td>
<td>0.376866</td>
</tr>
<tr>
<td>-0.090427 - 0.049821i</td>
<td>0.103243</td>
</tr>
<tr>
<td>-0.090427 + 0.049821i</td>
<td>0.103243</td>
</tr>
</tbody>
</table>

* Lag specification AR2

5. Empirical Findings

The empirical evidence suggests that from the third quarter of 1989 to third quarter of 2010, the real as distinct from the nominal change in US national income has the most significant impact on manufacturing growth when the values of employment in the manufacturing and service sectors, corporate tax receipts (a proxy of taxes), and the imports of manufacturing goods are presumed to be invariant. The findings of the regression model generally mirror some of the cogent arguments in the literature.

It is striking that the changes in employment in the manufacturing sector did not significantly affect the growth of manufacturing output. The literature has extensively attributed this relationship to innovation and productivity. An examination of Figure 2 is equally revealing.

The descriptive data show that from 1987 to 2010 the changes in manufacturing output (MANUG) outpaced changes in manufacturing employment (MEG), albeit with possible lag effects; so that when the employment is declining, output is increasing only to decline later on. But the empirical evidence does not suggest that the drop in manufacturing growth can significantly and convincingly be attributed to the drop in employment. The steepest decline in output relative to employment in the manufacturing sector occurred from the first quarter of 2007 to the third quarter of 2008 (a recessionary period, see the vertical lines). This downturn supports the theory that the performance of the manufacturing sector is highly contingent on economic cycles and productivity. The relationship between real income and changes in manufacturing output (as reported in Table 3) is instructive.
Figure 2: US Employment and Output in the Manufacturing Sector (average quarterly growth rates 1987-2010)

Table 3: Determinants of Manufacturing Growth (1989-2010) (p-values in parenthesis)

<table>
<thead>
<tr>
<th>Dependent Variable: Manufacturing Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimator: GLS (White heteroskedasticity-consistent standard errors &amp; covariance)</td>
</tr>
<tr>
<td>Included Observations: 85 (after adjustments for manufacturing intermediates and df)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Coefficients (p-values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in employment (manufacturing sector)</td>
<td>0.07 (0.77)</td>
</tr>
<tr>
<td>Change in employment (service sector)</td>
<td>-0.06 (0.25)</td>
</tr>
<tr>
<td>Change in real GDP</td>
<td>0.01 (0.00)**</td>
</tr>
<tr>
<td>Corporate tax receipts</td>
<td>0.003 (0.03)**</td>
</tr>
<tr>
<td>Imports of Manufacturing goods</td>
<td>0.00 (0.73)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.01 (0.5)</td>
</tr>
<tr>
<td>R²</td>
<td>0.49</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.46</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>15.24 (0.00)**</td>
</tr>
</tbody>
</table>

* Significance at the 90 percent level of confidence ** Significance at the 95 percent level of confidence
The empirical evidence suggests that the substitution effect from the service sector is not significant. This finding is noteworthy because even though structural changes are taking place in the US economy as a result of globalization, outsourcing is not unique to the manufacturing sector. The service sector has also faced a considerable amount of outsourcing, but also, increasing opportunity costs are associated with inter-sectoral shifts when structural changes occur in an economy; for example, retraining costs. Additionally, the inter-sectoral wage substitution effect is not equitable since the service sector pays much less (with some skill caveats).

Corporate tax receipts have not significantly and empirically hampered the growth of manufacturing output. This finding may seem counterintuitive, but the tax variable is understandably confounding for a variety of reasons: (i) there are surreptitious tax havens that can be exploited; (ii) some businesses have evidently avoided or evaded taxes; (iii) businesses have enjoyed episodic tax cuts; (iv) net corporate profits (profits after taxation) have increased exponentially; and (v) although the variable is aggregated, it shows no significant negative impact. However, this variable and corporate profits show no significant difference (not shown here for parsimony). A descriptive analysis might shed some light.

**Figure 3: Corporate Profit after taxes ($b) 1987-2010**

Many manufacturers believe that tax cuts have not gone far enough and they underscore the need for greater certainty under the tax code to encourage business investment (US Department of Commerce, 2004). Figure 3 shows the trajectory of net corporate profit from 1987 to 2010, with the steepest segment of the trend occurring between the fourth quarter of 1997 and the third quarter of 2006. Evidently, a sharp increase also occurred
between the fourth quarter of 2008 and the second quarter of 2010. Yet, the sharp increases in the growth of corporate profit have not empirically translated into increased growth of employment in the manufacturing sector. The risk aversion of manufacturers may plausibly but incompletely explain the relationship between taxes and manufacturing output or employment. This is because weak domestic and foreign absorption of manufacturing products and national income can also play a critical role in the revitalization of the sector. This study has not found imported manufacturing goods to be a significant deterrent or aid to the changes in manufacturing output.

Overall, the regression model shows very good interaction of the exogenous variables, with an F-statistic of 12.24. The coefficient of determination indicates that almost half of the variation in the dependent variable is explained by the regressors.

The next segment of this paper examines the response of manufacturing performance to economic shocks. It should be recalled from earlier analysis that two shocks are of interest: (i) shocks to real national income (GDPG) and (ii) shocks to manufacturing imports. Sequential and generalized shocks are examined, but for the purpose of brevity the generalized shocks are reported in Figure 4.

The impulse response (Figure 4) shows that manufacturing growth falls slowly in response to its own shock and continues to do so for about 8 quarters. The fall can be associated with unexpected changes in declining real national income and to some extent, manufacturing imports. The response of changes in manufacturing to real output shock is much more persistent than that of the import shock, suggesting that the response to import shock tends to fade away more rapidly than the response to the real national income shock. These results are not radically different from shocks that are sequentially ordered (Cholesky innovations). The generalized shocks, which are not susceptible to causal-ordering and multiple responses, have been considered to be sufficient for the purpose of this analysis.

Figure 4: Response of US Manufacturing to Generalized income and import Shocks\textsuperscript{b}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Response of US Manufacturing to Generalized income and import Shocks\textsuperscript{b}}
\end{figure}

\textsuperscript{b} Manufacturing growth (MANUG); GDP growth (GDPG); and manufacturing imports (MIMP)—Generalized Innovations.
The significant results of Granger-Causality test are reported in Table 4. As expected, past values of GDP growth, tax receipts, and employment in the manufacturing sectors show predictive power over the performance of manufacturing output. The import of manufacturing goods does not show isolated strength, but contributes to the aggregate predictive power of the variables considered (see regression 1).

Although the variables can collectively predict changes in manufacturing imports, manufacturing output and changes in employment in the manufacturing sector have individual capacities to forecast changes in manufacturing imports (see regression 2). Past values of manufacturing output, corporate taxes, and employment in the manufacturing and service sectors Granger-cause GDP growth, but manufacturing imports do not show a forecasting potential for GDP growth (see regression 3). This is not surprising because the variable constitutes part of the aggregate leakage rather than any form of injection.

While globalization and productivity have influenced the level of employment in the manufacturing sector, manufacturing output, GDP growth and manufacturing imports are capable of predicting changes in employment in the manufacturing sector (see regression 4).

Table 4: Granger-Causality Test  (p-values and Chi-Square Statistic in parenthesis)a

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Manufacturing Output (1)</th>
<th>Manufacturing Imports (2)</th>
<th>GDP Volatility (3)</th>
<th>Employment (manufacturing) (4)</th>
<th>Tax Receipts (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Output</td>
<td>NA</td>
<td>0.08*</td>
<td>0.02**</td>
<td>0.005**</td>
<td>0.48</td>
</tr>
<tr>
<td>Manufacturing Imports</td>
<td>0.42</td>
<td>NA</td>
<td>0.76</td>
<td>0.89</td>
<td>0.08*</td>
</tr>
<tr>
<td>GDP Volatility</td>
<td>0.12*</td>
<td>0.45</td>
<td>NA</td>
<td>0.0002**</td>
<td>0.05**</td>
</tr>
<tr>
<td>Employment (manufacturing)</td>
<td>0.02**</td>
<td>0.001**</td>
<td>0.16*</td>
<td>NA</td>
<td>0.20</td>
</tr>
<tr>
<td>Employment (service sector)</td>
<td>0.18*</td>
<td>0.32</td>
<td>0.04**</td>
<td>0.07*</td>
<td>0.00*</td>
</tr>
<tr>
<td>Tax Receipts</td>
<td>0.07*</td>
<td>0.84</td>
<td>0.12*</td>
<td>0.04**</td>
<td>NA</td>
</tr>
<tr>
<td>All</td>
<td>(28.37)</td>
<td>(22.70)</td>
<td>(20.93)</td>
<td>(74.07)</td>
<td>(49.69)</td>
</tr>
<tr>
<td>Chi Square</td>
<td>0.002**</td>
<td>0.01**</td>
<td>0.02**</td>
<td>0.00**</td>
<td>0.00**</td>
</tr>
</tbody>
</table>

a. 2 lags Granger-Causality (Schwartz criterion) NA = not available as an exogenous variable
* significance at the 90 percent level of confidence  ** Error tolerance of 5%

However, lagged values of manufacturing imports do not provide isolated and convincing predictive power over employment in the manufacturing sector. All the variables show a capacity to collectively predict changes in corporate tax receipts, but manufacturing imports, changes in national income, and changes in employment in the service sector show individual capacities to forecast tax receipts (see regression 5).
The empirical evidence shows that some of the variables exhibit dual-causal relationships. Changes in GDP are capable of forecasting manufacturing output, just as manufacturing output is capable of forecasting GDP changes. Similarly, employment in the manufacturing sector is capable of predicting changes in manufacturing output; just as manufacturing output is capable of predicting changes in employment in the manufacturing sector. The volatility in US national income is capable of predicting changes in employment in the US manufacturing sector just as changes in employment in the US manufacturing sector are capable of predicting changes in national income. As such, the core macro variables generally tend to show a great degree of interaction and predictive relevance.

6. Conclusion
Globalization has brought about structural changes to various economies of the world, but the US manufacturing sector has been very sensitive to the structural changes of globalization. The literature provides diverse theories for changes in the manufacturing sector, but the most prominent theories have focused on internationalization and the impact of globalization on employment.

The empirical evidence suggests that from the third quarter of 1989 to third quarter of 2010, changes in US national income has the most significant impact on the changes in manufacturing when the values of employment in the manufacturing and service sectors, corporate tax receipts and the imports of manufacturing goods are presumed to be invariant. The substitution effect of the service sector has not been found to be significant, possibly because the sector is also prone to outsourcing; but also because increasing opportunity costs are associated with structural changes and resource reallocation. Additionally, the service sector can be less attractive because of the sectoral-wage differential. Corporate tax receipts have not significantly and adversely affected changes in manufacturing, possibly because of corporate profits, tax breaks, and tax evasion or avoidance. Of course, the consumption of manufacturing goods is ultimately contingent on national income, distribution, and domestic and foreign economic shocks.

Impulse response shows that manufacturing growth can prospectively respond negatively to adverse income and import shocks, with the effects of the income shock outlasting those of the import shock. Though US manufacturing productivity has increased considerably as a result of technological innovation, changes in national income are capable of predicting US manufacturing output, just as manufacturing output is capable of predicting changes in US national income. Similarly, a dual-causal relationship can be found to exist between changes in employment in the manufacturing sector and changes in US national income.

The overall empirical evidence suggests that as a policy issue, manufacturing output may not be entirely dependent on globalization, but a combination of factors, of which changes in national income and domestic and foreign absorption are paramount. The effects of corporate taxes and net corporate profits on the performance of manufacturing sector have not been discovered to be very precise. Increasing US national income to foster domestic and foreign linkages to the manufacturing sector remains a major policy challenge for the revitalization of employment in the manufacturing sector after the most recent wave of globalization.
References


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